Module 2

Principles of spirits' production

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The four stages of spirits' production

raw material

1. processing a raw material

to create a sugary liquid or usable solid

2. alcoholic fermentation

to create an alcoholic medium (liquid, semi-solid or solid) and congeners

3. distillation

to select and concentrate alcohol and congeners

4. post-distillation operations

to ensure the spirit has the correct flavour, colour, sweetness, texture and alcoholic strength

spirit

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Stage 1: Processing a raw material

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Stage 1: overview

Provides

- simple carbohydrates

  glucose, fructose and sucrose (fermentable sugars)

- complex carbohydrates

  starch, fructans

- starch and fructans must be converted to sugar
- congeners = flavours

Output of stage 1

- sugary liquid
- usable solid (Asian spirits)

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Types of raw material

Fermentable sugars

- fruit *(sessions 6 and 7)*
- sugar cane *(session 9)*

Starch

- grains and potatoes *(sessions 3, 4, 8 and 11)*

Fructans

- agave *(session 10)*

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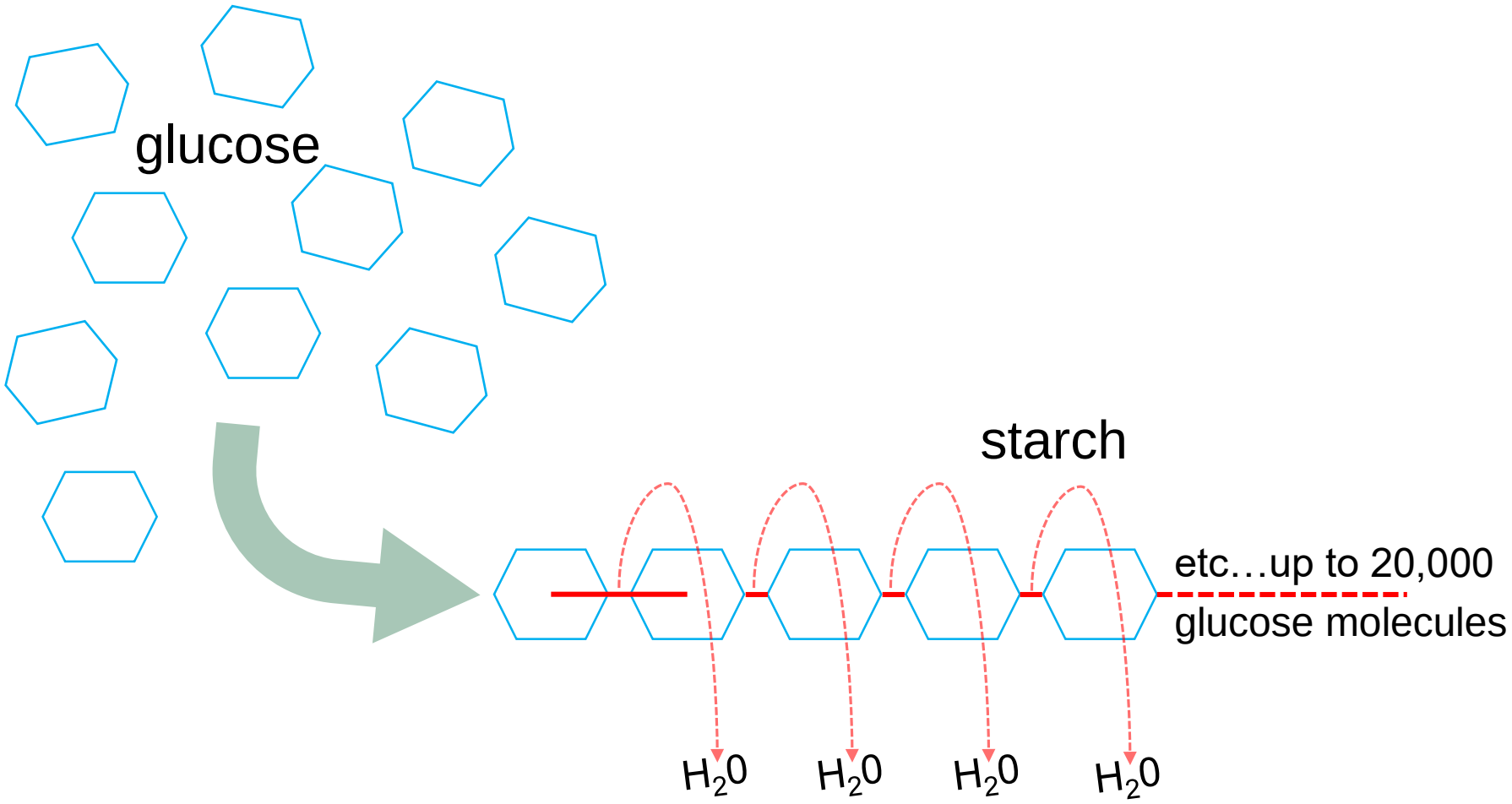
Starch formation



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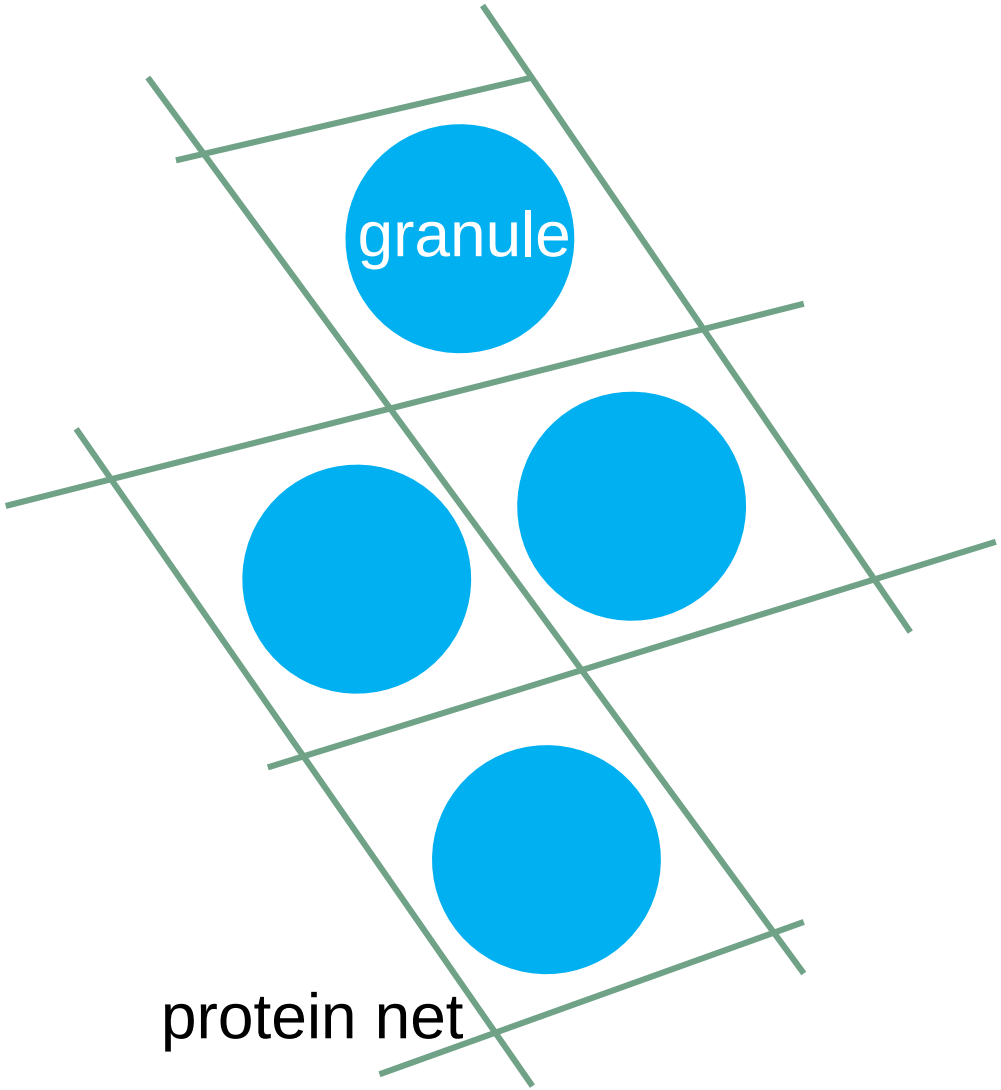
Starch granules



Potatoes

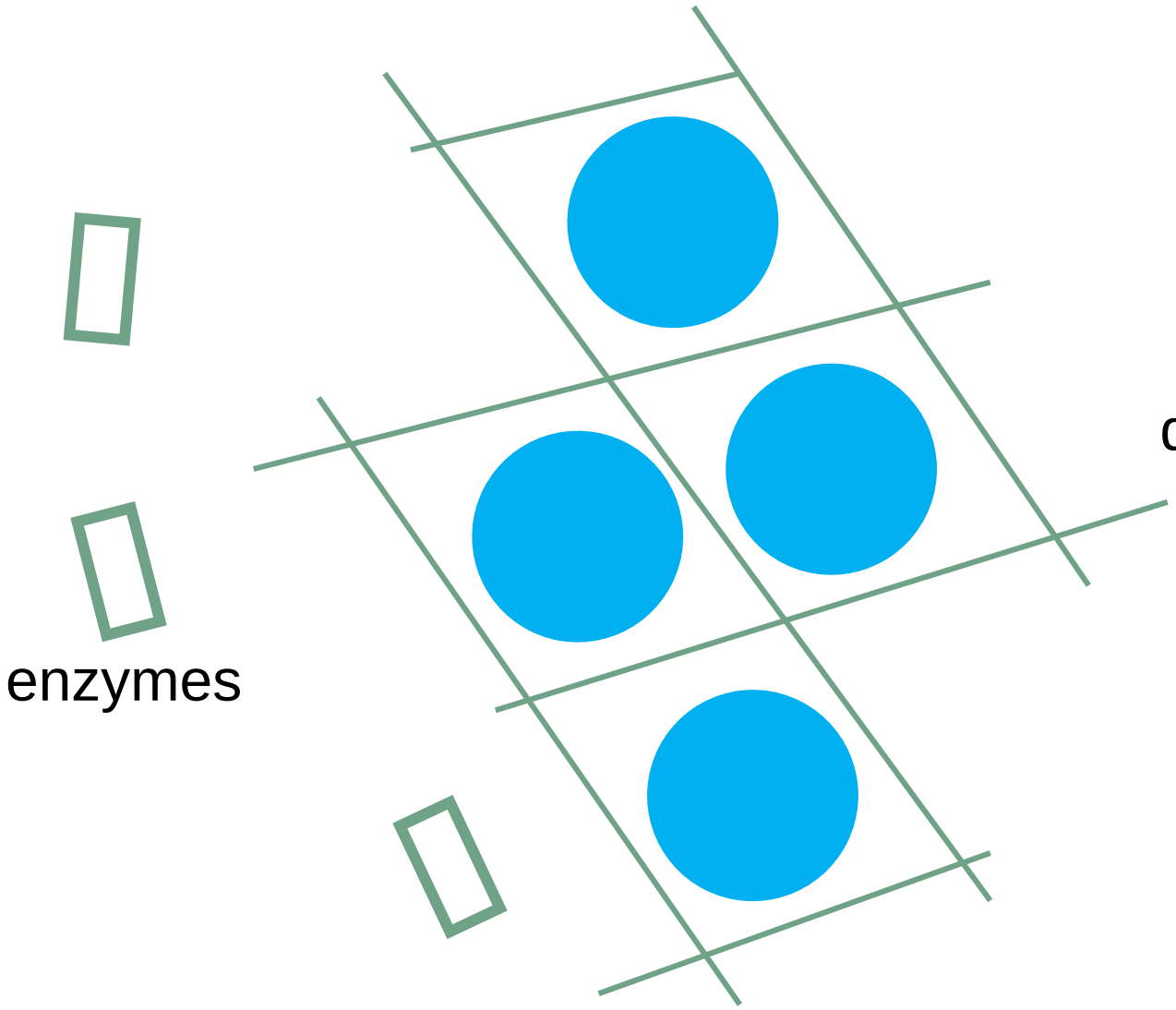
stored in living cells

Grains

stored in a protein net

Modification

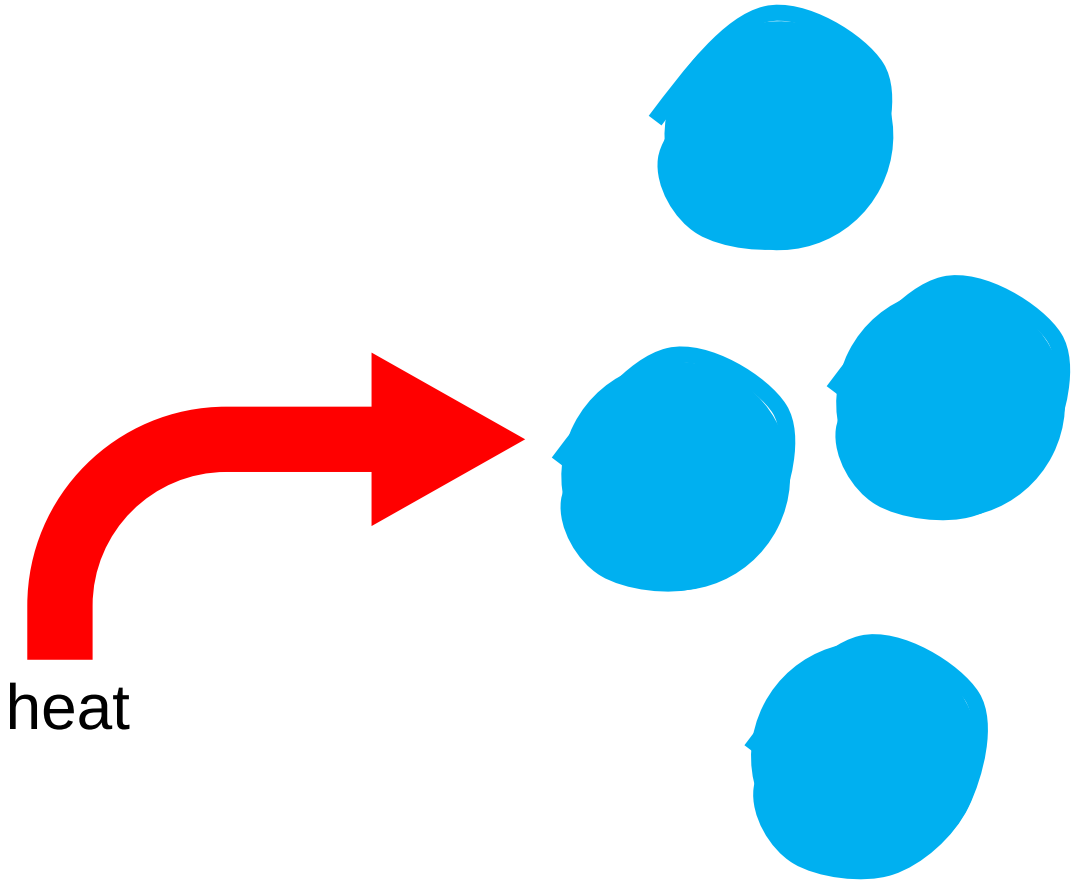
grains only



enzymes break down protein net

high heat could also be used

Gelatinisation



starch balls unravel and become soluble

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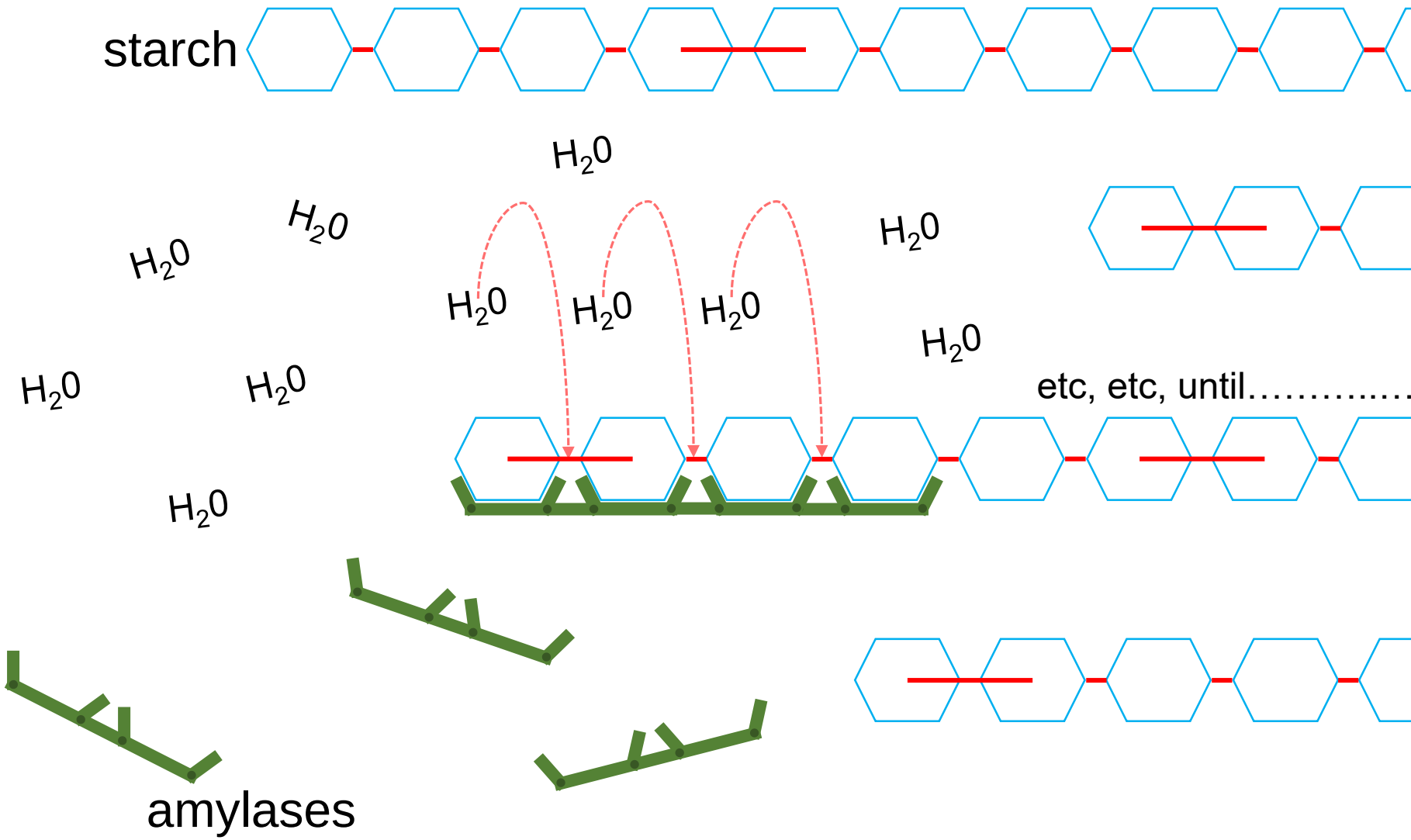
Enzymatic hydrolysis



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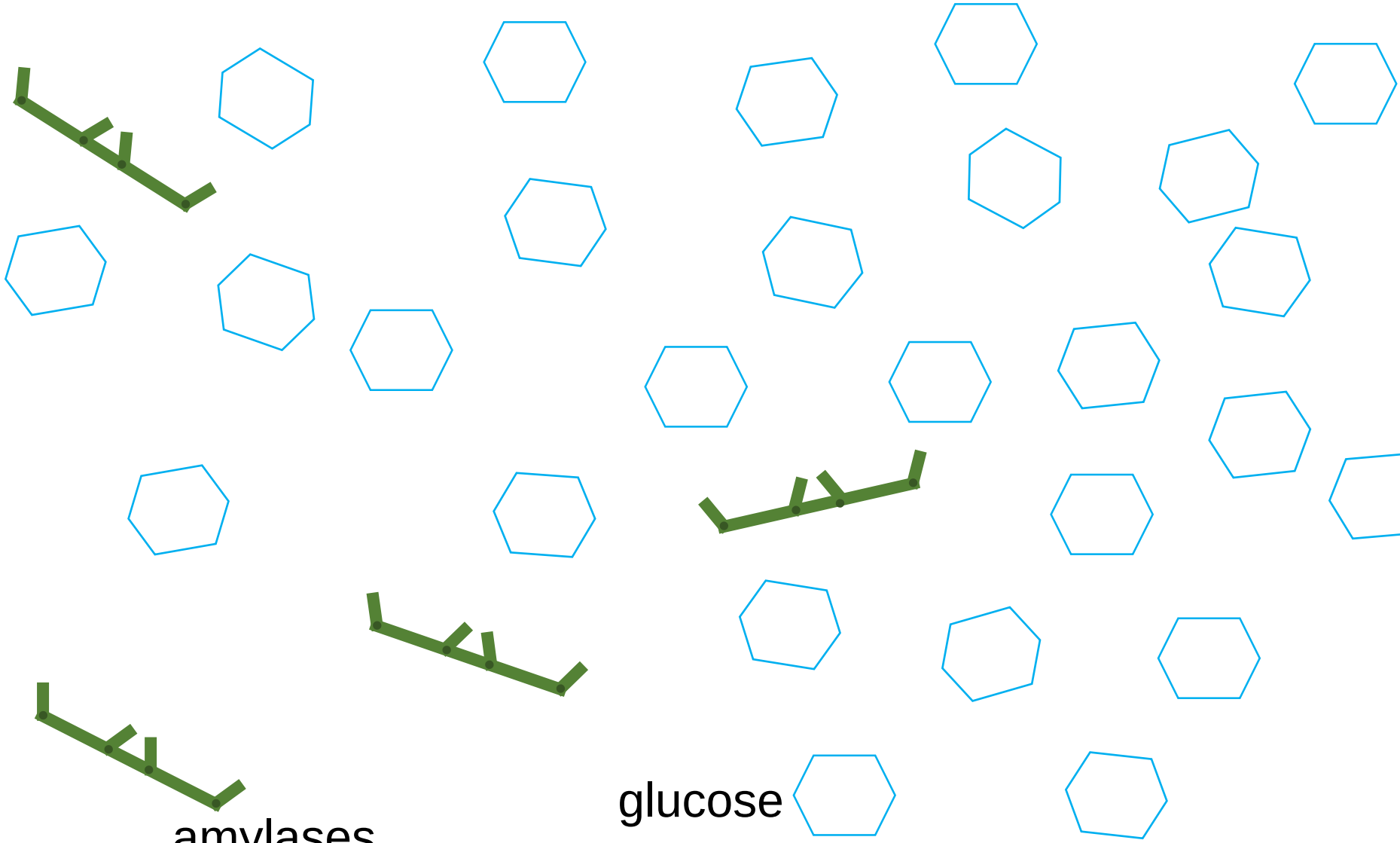
Enzymatic hydrolysis



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Starch

grains *potatoes*

- starch formation
- starch granules
- protein net
- modification
- gelatinisation
- enzymatic hydrolysis

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Stage 2: Alcoholic fermentation

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Stage 2: overview

Yeast

- produce ethanol and many other compounds

Approaches to fermentation

- liquid-state and sequential
- semi-solid-state/solid-state and parallel *(session 8)*

Bacteria

- malolactic conversion
- flavour creation

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Yeast

Requirements

nutrients

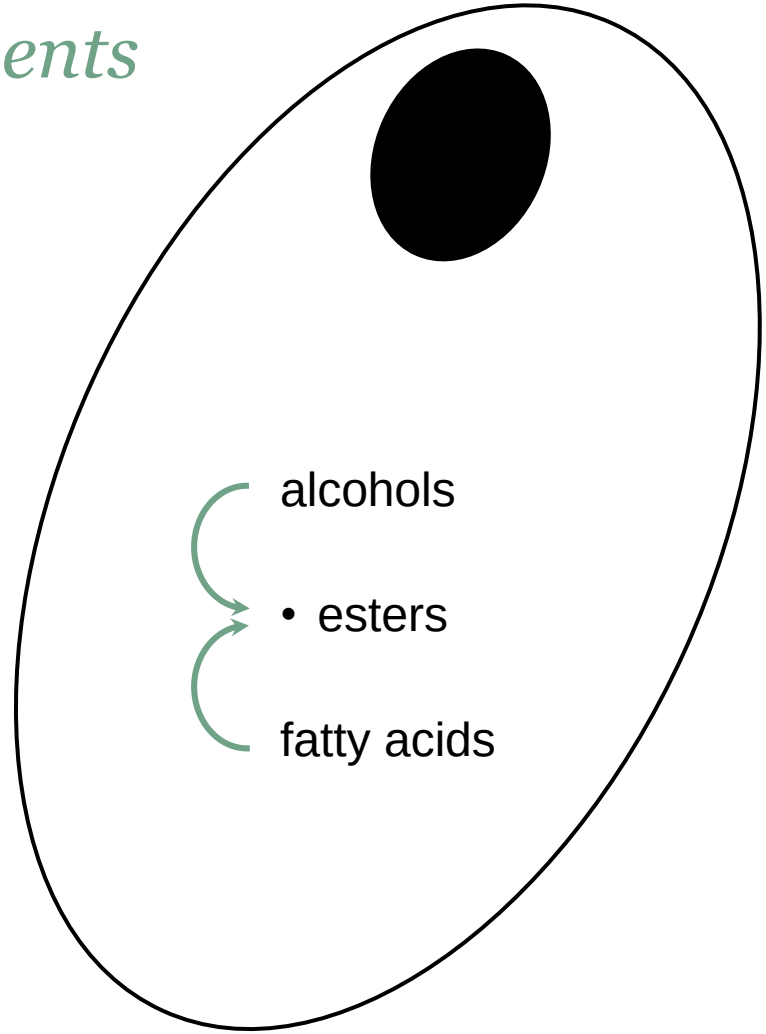
- sugar
- nitrogen

environment

- acidic
- warmth

Types

cultured
ambient



Outputs

sugar metabolism

- ethanol
- CO_2
- heat

other

- methanol
- fusel alcohols
- fatty acids
- esters
- sulfur compounds

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Sequential fermentation

majority of fermentations use this method

raw material → create a sugary liquid → alcoholic fermentation → alcoholic liquid

starch and fructans will need to undergo conversion

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Bacteria

Malolactic conversion

- winemaking, after alcoholic fermentation
- malic acid + lactic acid bacteria → lactic acid

Flavour creation

- during/after fermentation
- subtle *(some Scotch)*
- pronounced *(some rums, Mezcals, Baijius)*

} short and long fermentations

Stage 3: Distillation

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Stage 3: overview

part 1

Boiling and volatility

Concentration and selection

Reflux and rectification

- liquid/gas interaction
- managing reflux

Fractions in an alcoholic liquid

Flavour management in a still

- Maillard reactions and esterification
- copper, clay and sulfur
- vacuum *(sessions 8 and 11)*

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Boiling and volatility

ethanol and water

water	*ethanol*	*boiling point* (standard atmospheric pressure)	*volatility*
100%	0%	100°C / 212°F	higher → least
50%	50%	82.4°C / 180°F	
0%	100%	78.3°C / 173°F	lower → most

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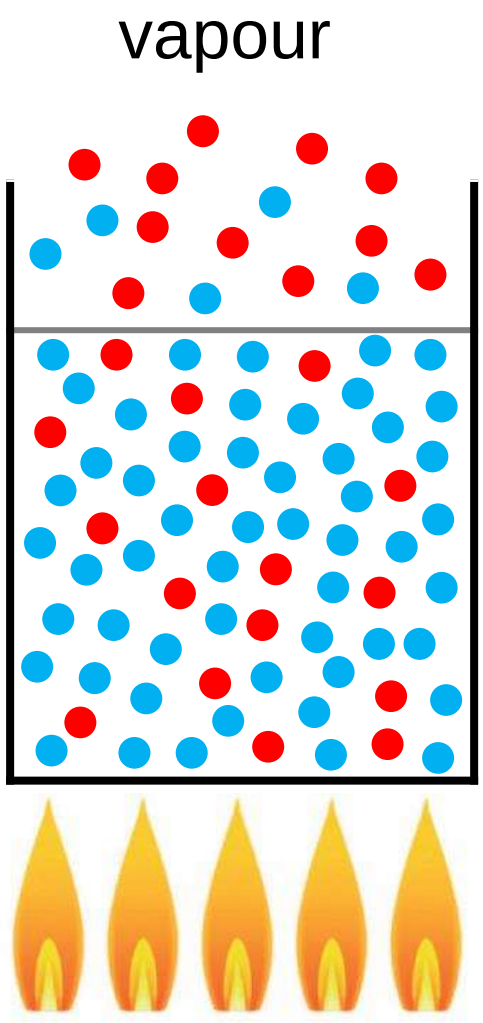
Concentration and selection

ethanol and water



- vapour is made up of gas and liquid droplets

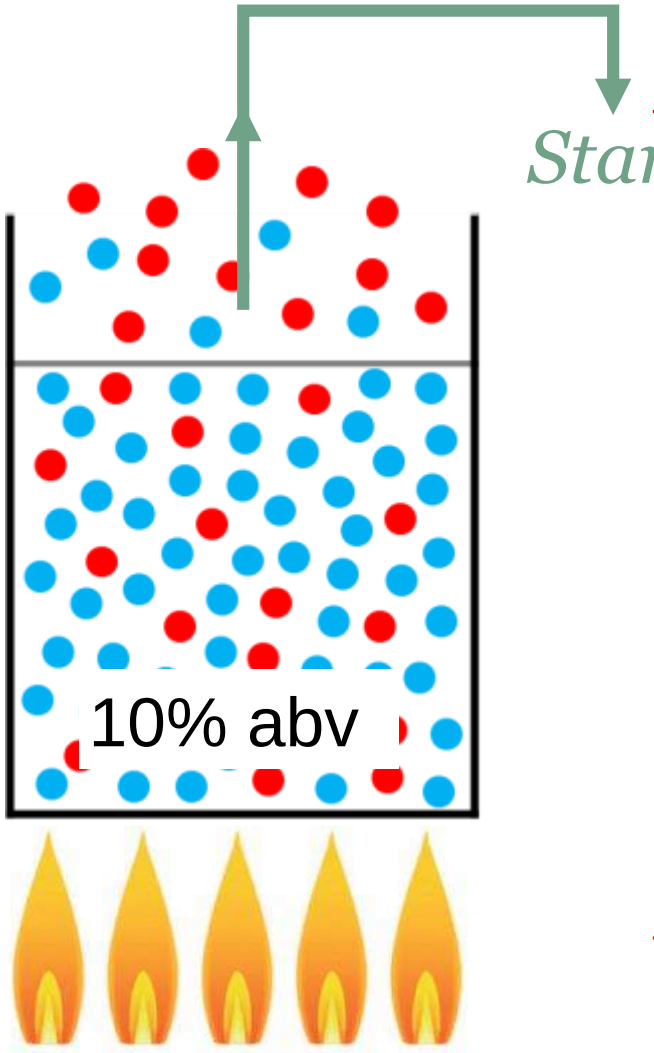
- **vapour above a boiling mixed liquid will always be mixed**

but

the more volatile fraction will be more concentrated in the vapour

Concentration and selection

ethanol and water



	flow	*cumulative*
Start	50% abv	50% abv

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Concentration and selection

ethanol and water

original liquid	*after collecting 1L*	
	first liquid collected	*remaining original liquid*
900L water	0.5L water	899.5L water
100L ethanol	0.5L ethanol	99.5L ethanol
1000L total	*1L total*	*999L total*
10% abv	50% abv	9.9% abv

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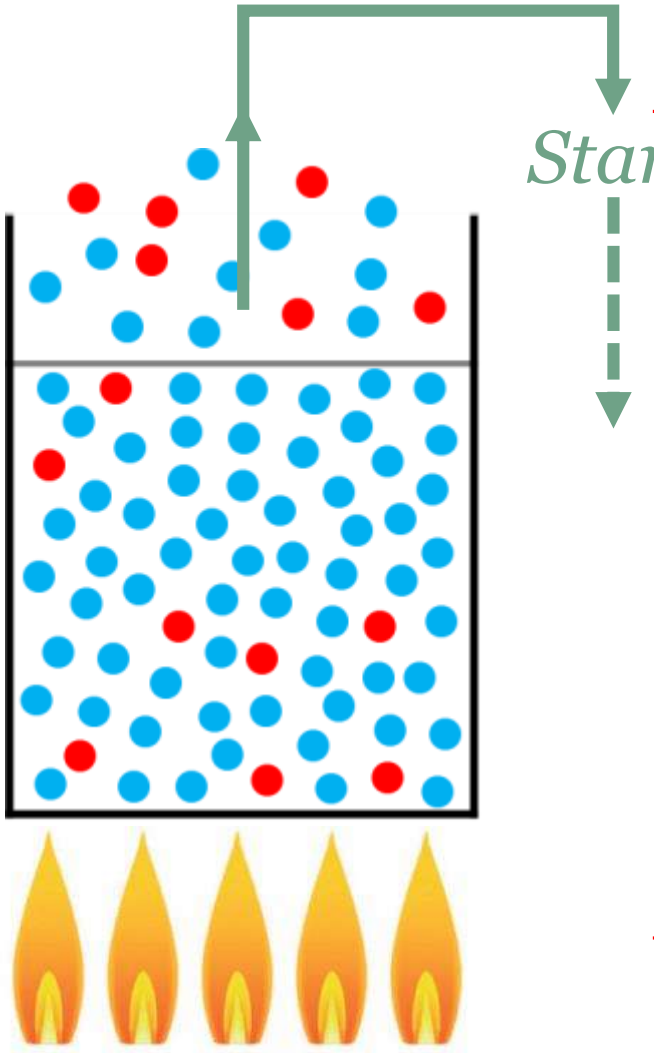
Concentration and selection

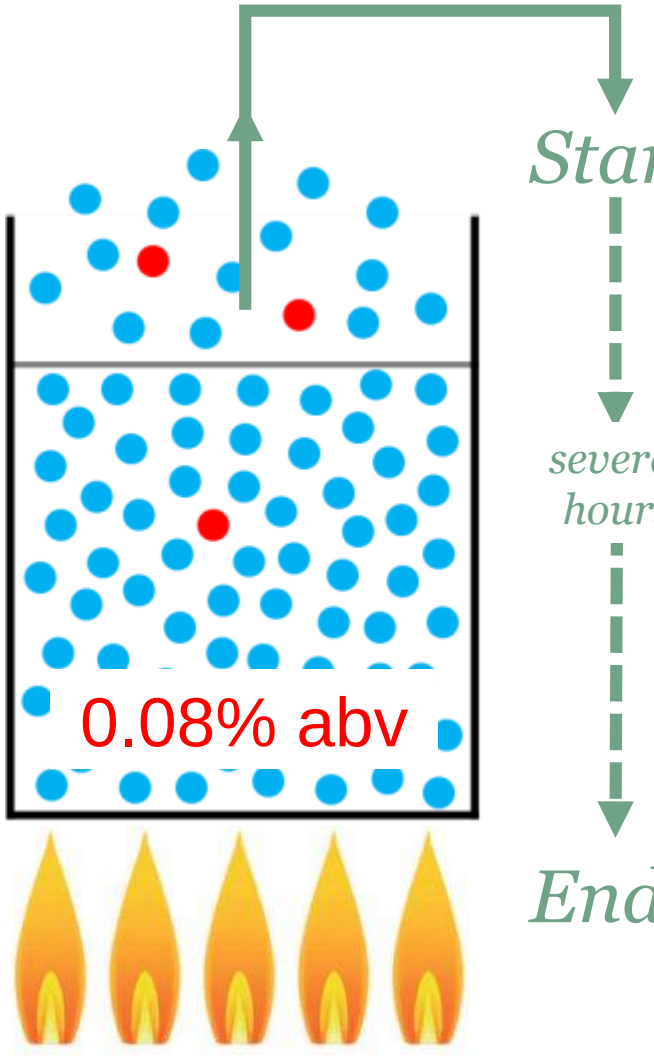
ethanol and water



	flow	*cumulative*
Start	50% abv	50% abv
	both values drop	
	40% abv	

Concentration and selection

ethanol and water



	flow	*cumulative*
Start	50% abv	50% abv
several hours		40% abv
End	1% abv	25-30% abv

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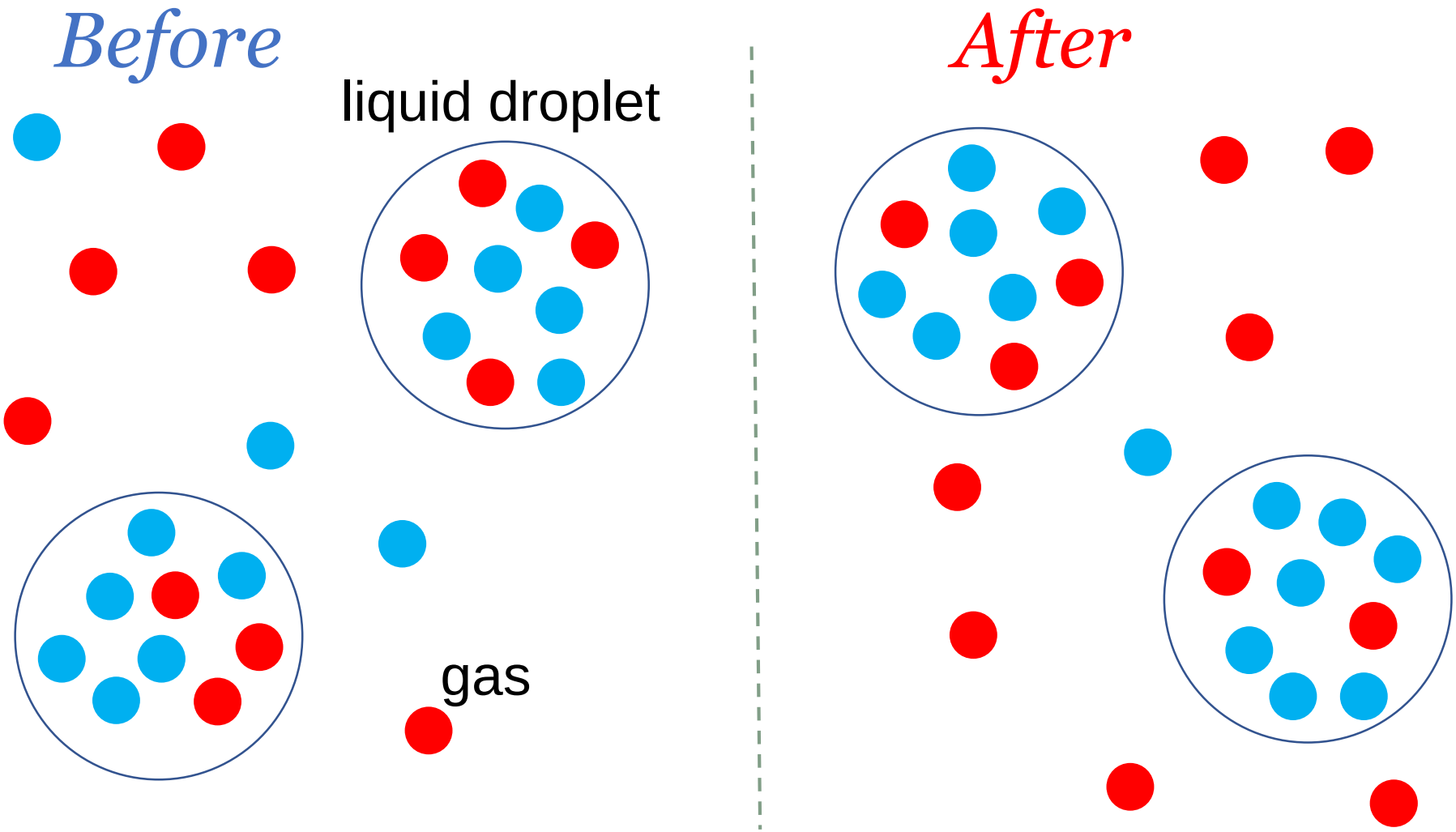
Reflux and rectification

ethanol and water



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Managing reflux

if you

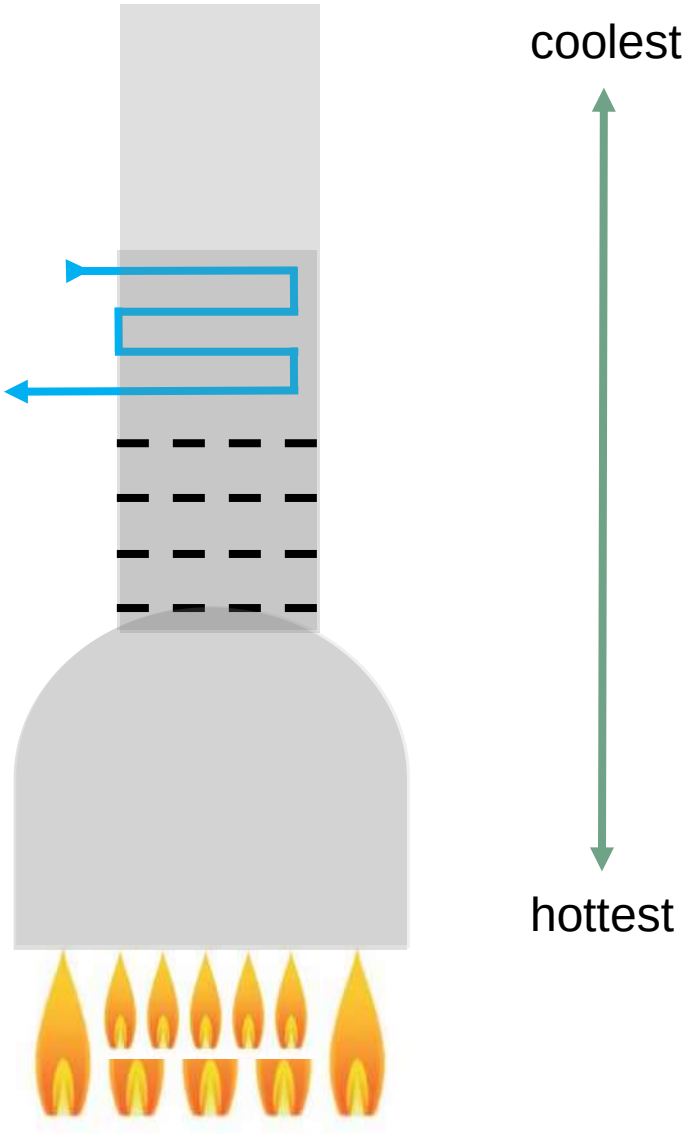
control the temperature gradient

you

control the amount of reflux and rectification

Options

- height
- heat input
- dephlegmator (head condenser)



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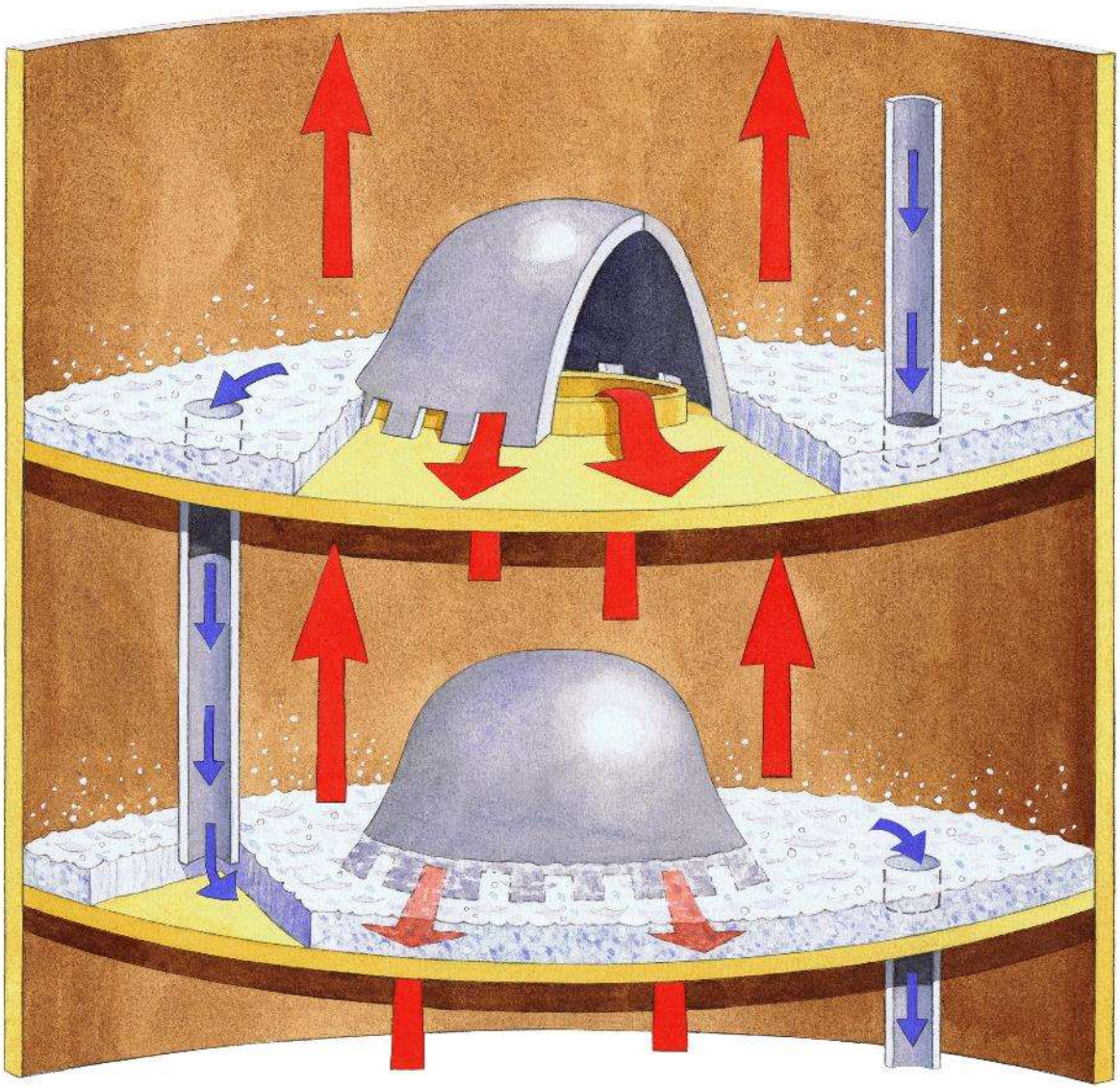
Bubble cap plates



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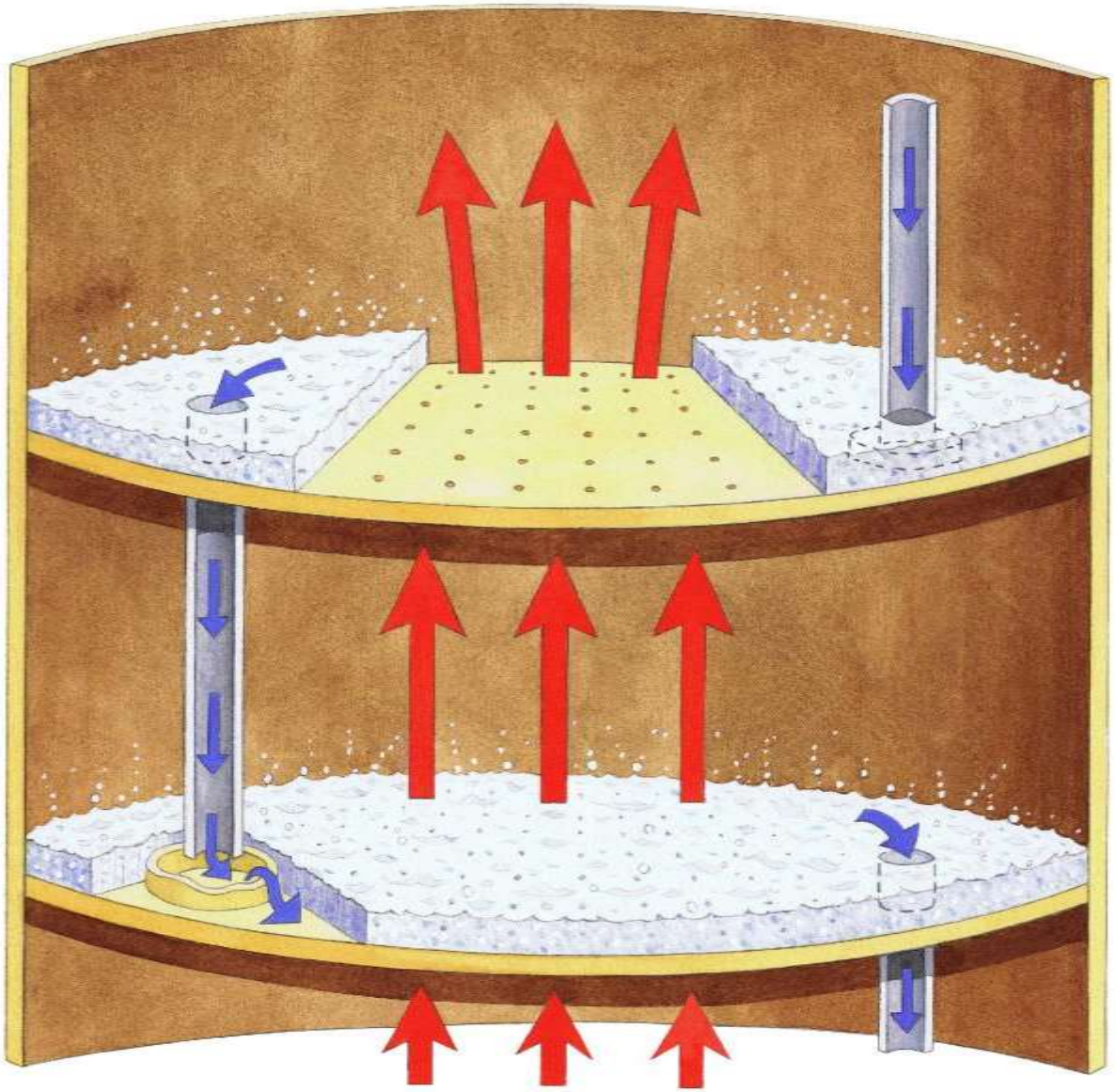
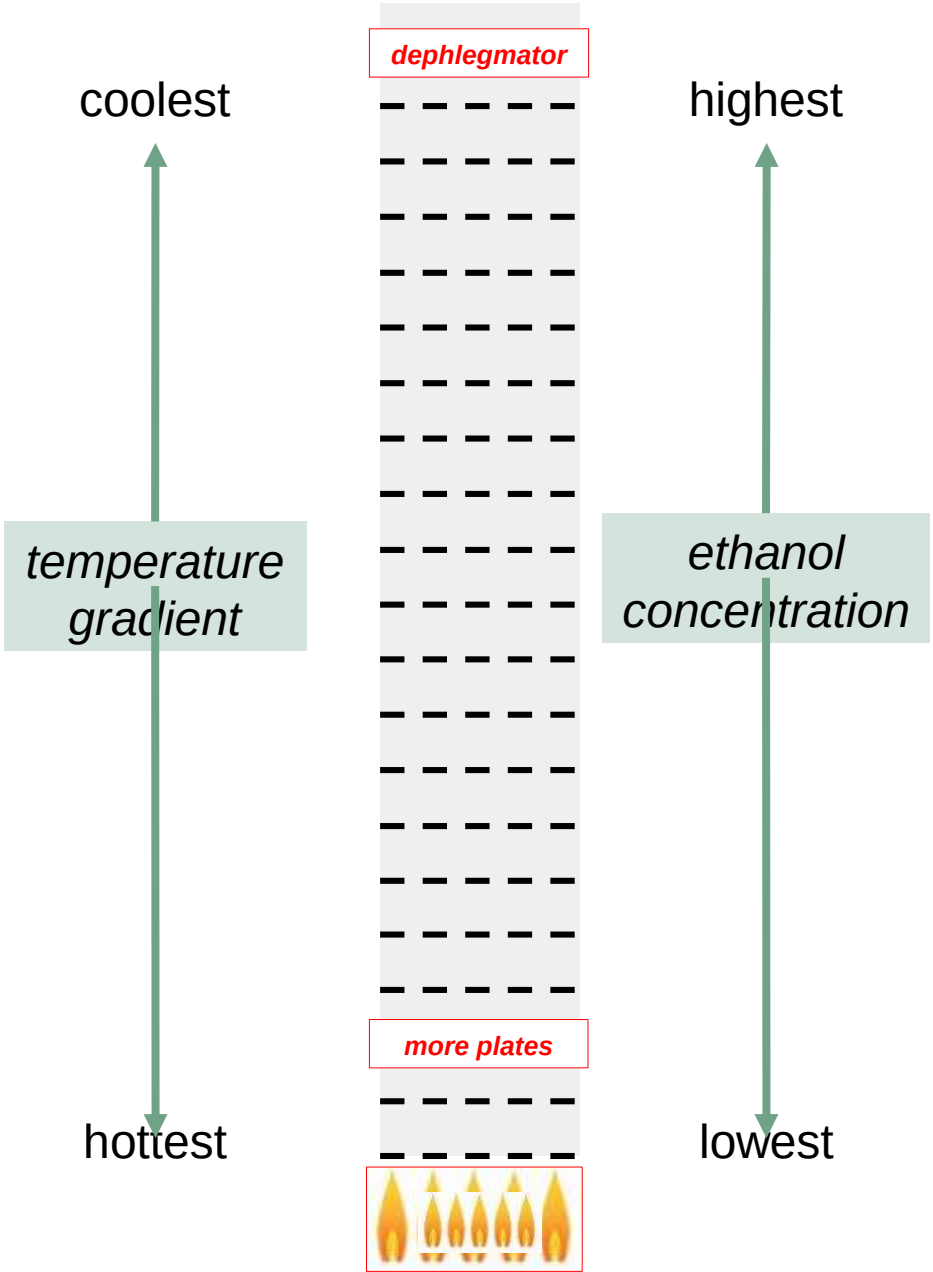
Sieve plates



Reflux in column stills



Fractions in an alcoholic liquid

Group 1

- methanol & other fractions with a low boiling point

Group 2

- ethanol & fractions with a similar boiling point

Group 3

- fusel alcohols & fractions with a high boiling point

Group 4

- fractions that never leave the still

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Maillard reactions and esterification

Maillard reactions

- sugar + amino acid → flavours

Controls

- heating method & solids in the still

Esterification

- alcohols + fatty acids → esters

Controls

- heating method and yeast cells in the still

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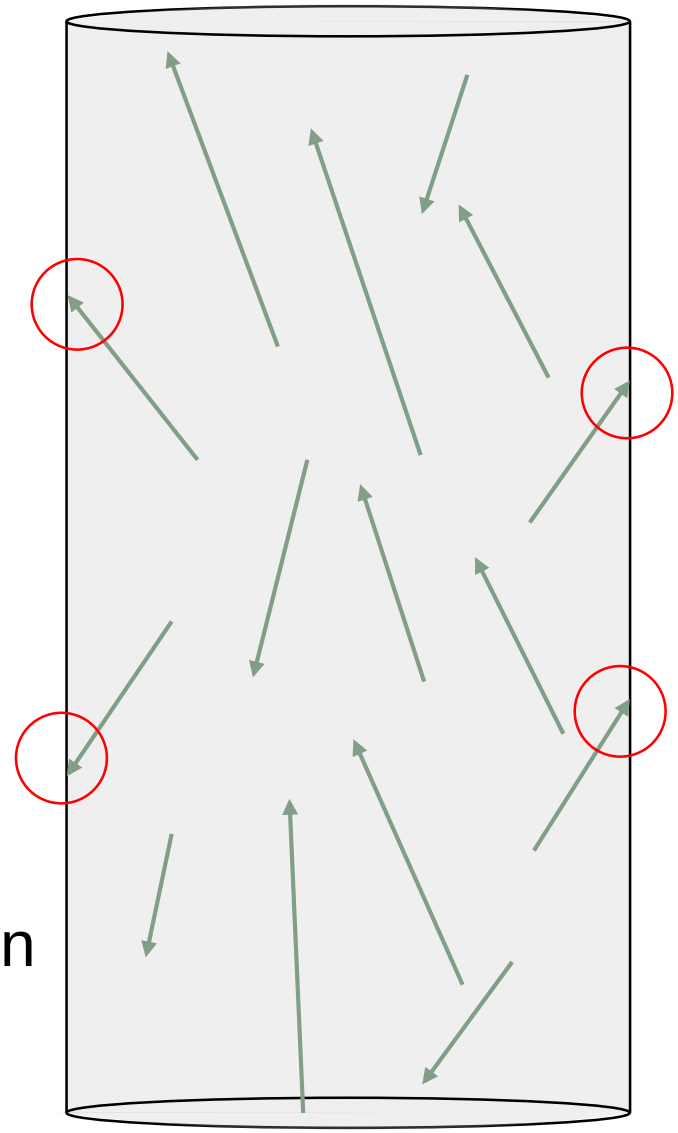
Copper, clay and sulfur

Sulfur compounds

- unpleasant smelling
- concentrated by distillation

Removal

- interaction with surface of the still
- level of interaction can be controlled



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Exercise

consider the simplified distillation model using a mixed liquid containing only ethanol and water

Team 1

- describe what happens to the abv of the flow coming off the condenser and explain why this change happens

Team 2

- describe what happens during reflux and explain how it is linked to rectification

Team 3

- list the three methods, other than rectification plates, that can be used to manage reflux
- take one of these three methods and explain how it works

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Stage 3: overview
part 2

Double pot still distillation

- Scottish model (simplified)
- limits of pot stills

Continuous column still operation

- dynamic equilibrium
- conditions for continuous operation

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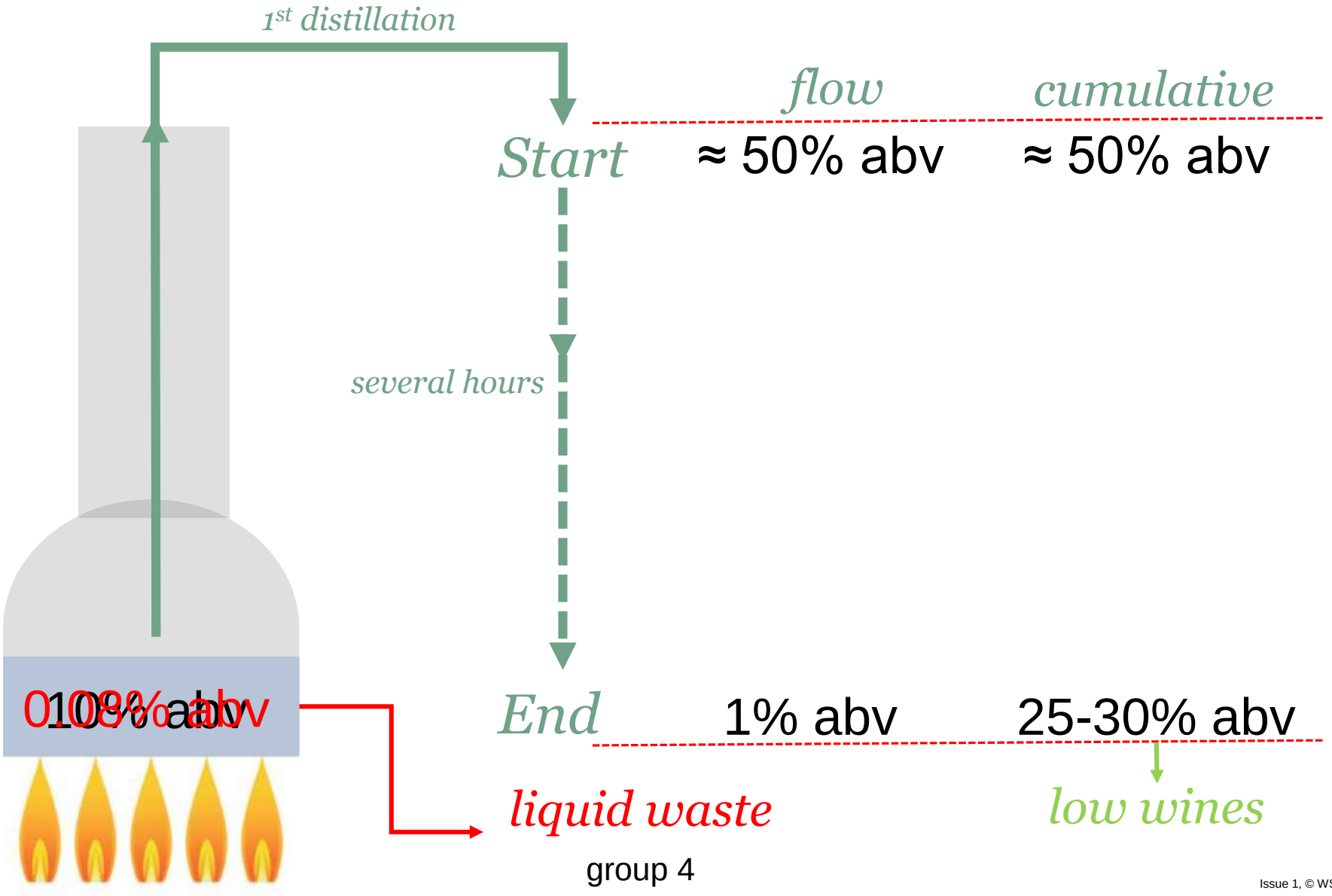
Pot stills

simplified model



group 4

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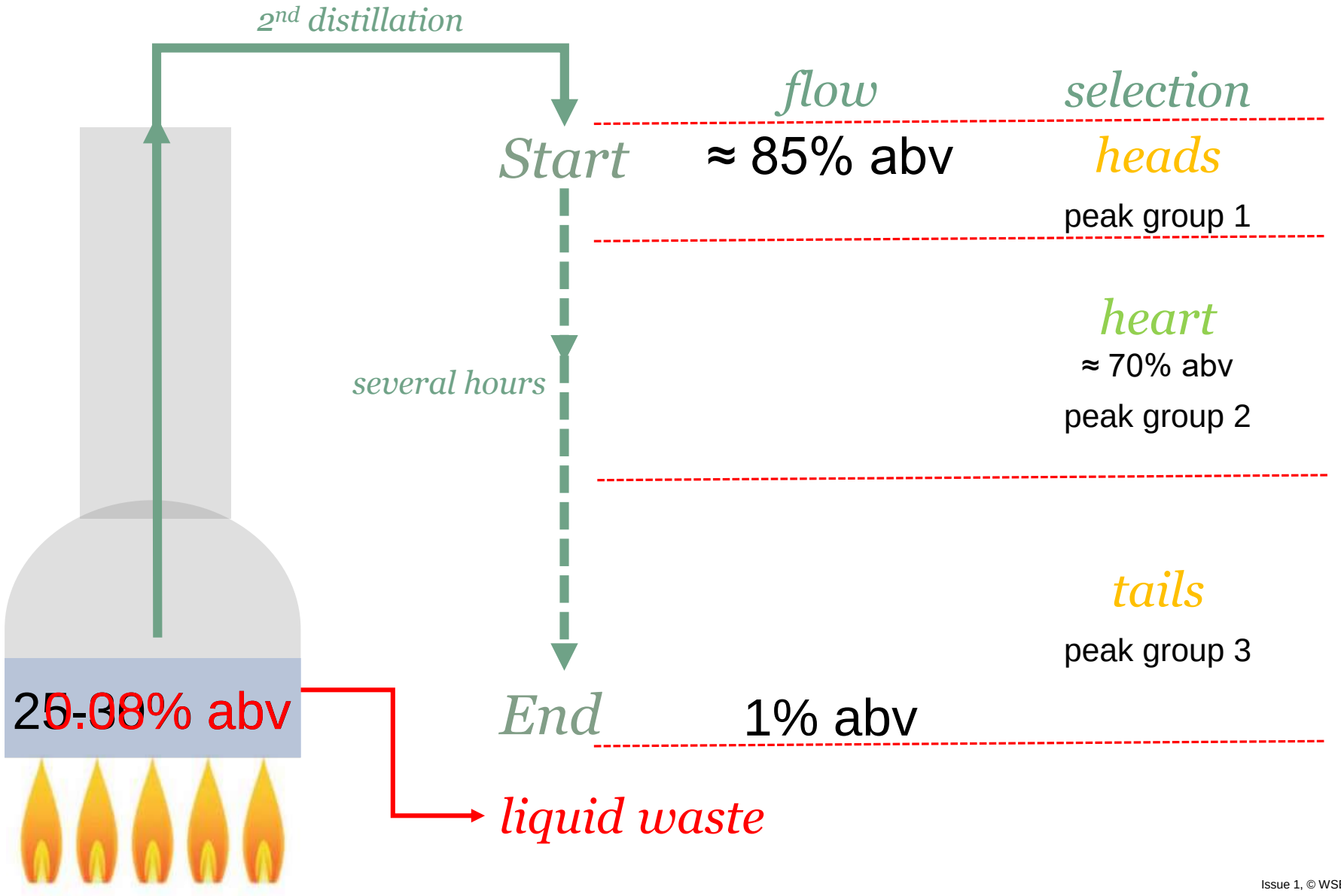
Pot stills
simplified model



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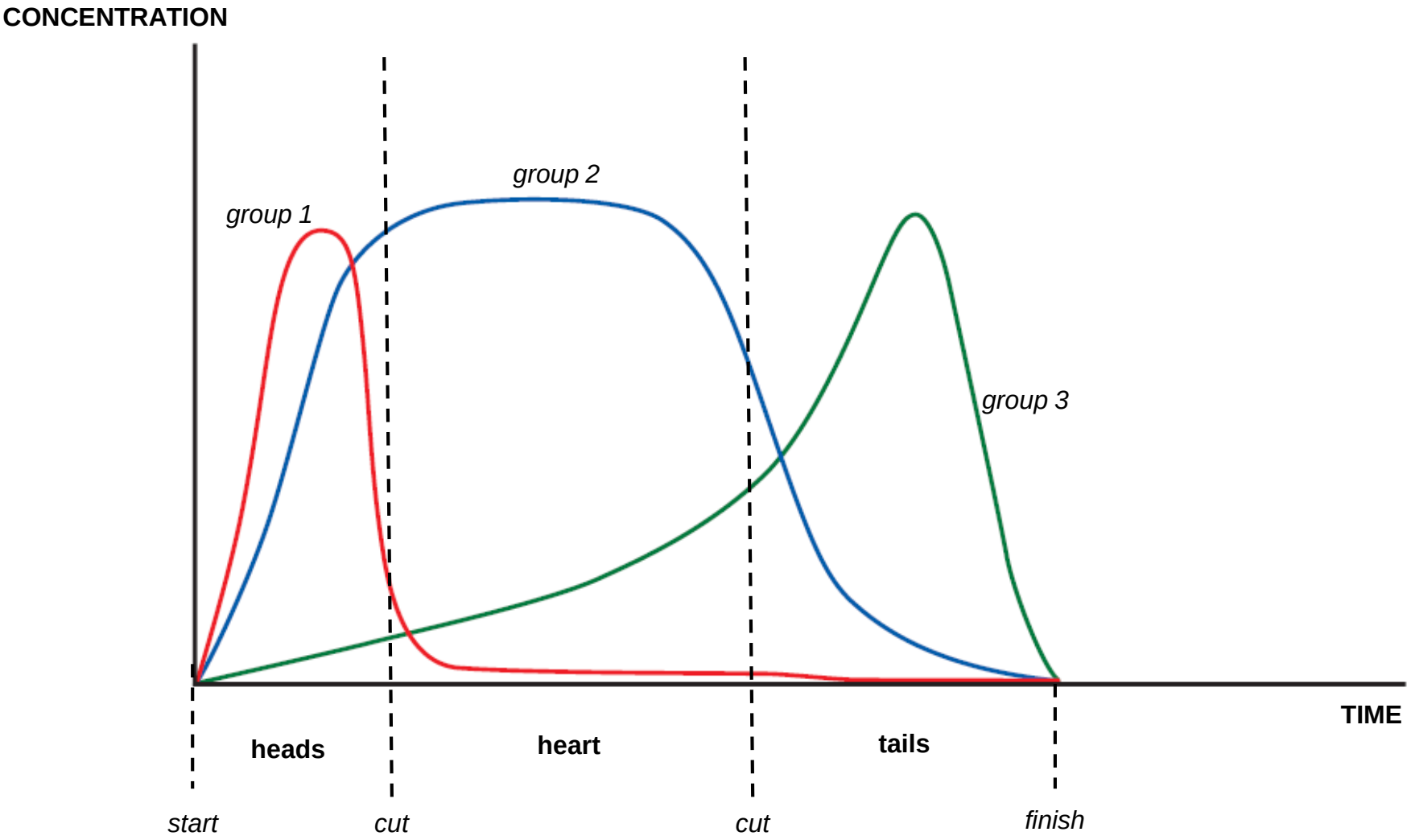
Pot stills
simplified model



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Pot stills
simplified model

what you want comes with too much of what you do not want

- ethanol
- group 2 fractions

double distillation
cuts
recycling

- water
- group 1 fractions
- group 3 fractions

Advantage

- complex mix of fractions and flavours

Challenges

- cannot produce a highly rectified spirit
- how do you manage the level of group 3 fractions?

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Pot still distillation

Approaches covered in detail

- Scottish double pot still distillation *(session 3)*
- Cognac double pot still distillation *(session 6)*
- Caribbean pot + double retort, single distillation *(session 9)*
- Mezcal clay stills, double pot still distillation *(session 10)*

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Exercise

describe and explain how the equipment or techniques listed below can affect the style of a spirit produced in a pot still

Team 1

- your still has a dephlegmator

Team 2

- the liquid in your still is boiling more vigorously

Team 3

- you change the timing of the cuts, try various options

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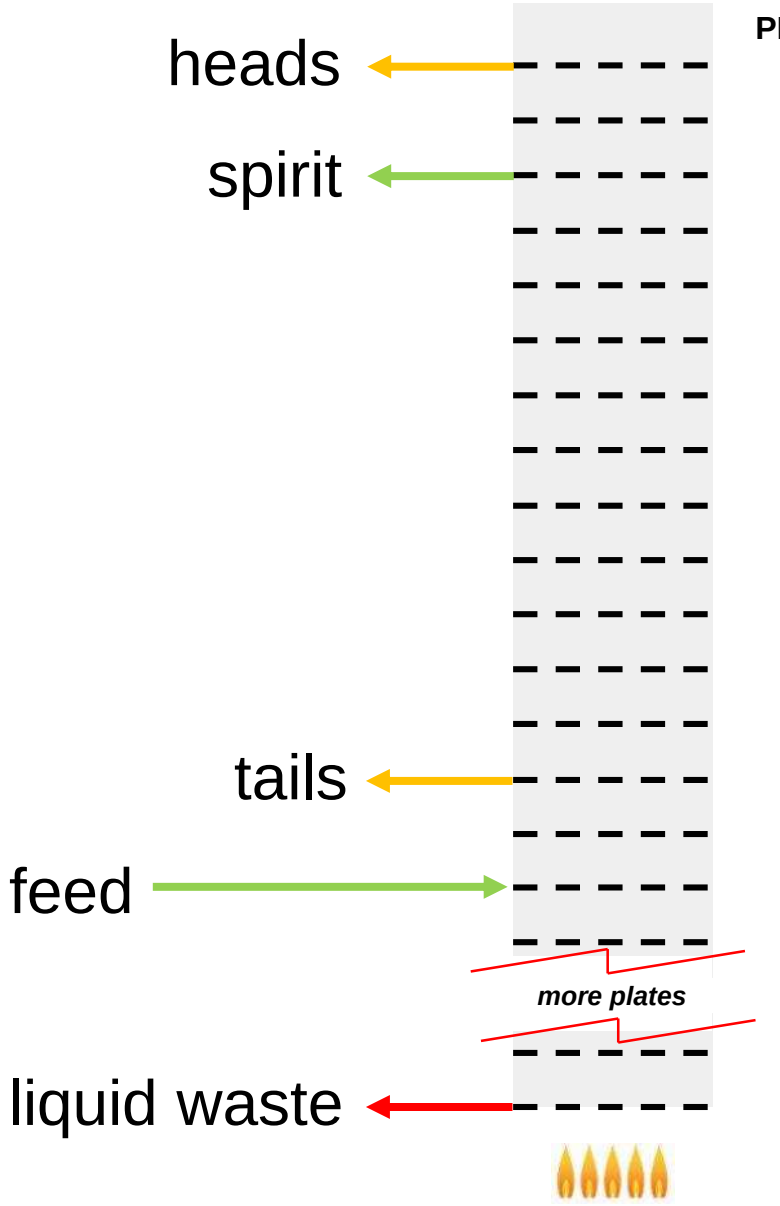
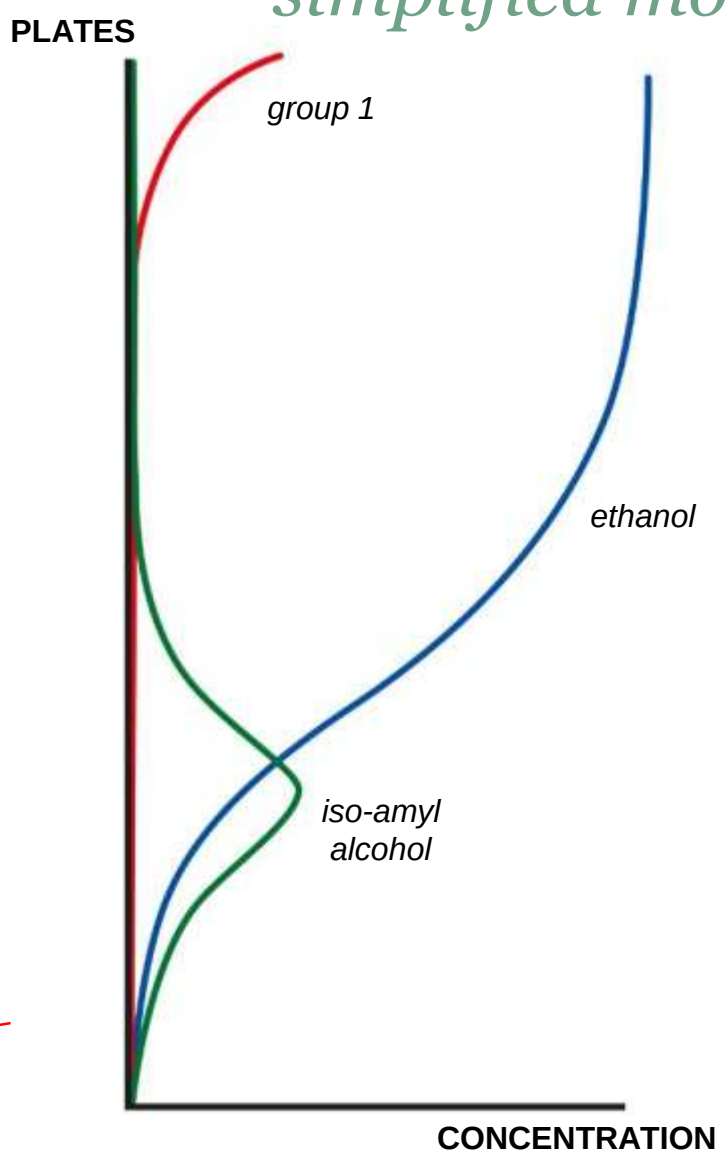
Single-column still

simplified model





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Dynamic equilibrium

start up still

concentration of fractions on the plates is constantly changing → rate of change slows → concentration of fractions on the plates becomes constant

dynamic equilibrium

movement of the fractions up and down the still never stops

To maintain dynamic equilibrium

- temperature gradient remains constant
- composition of feed remains constant
- flow rates in and out of still remain equal

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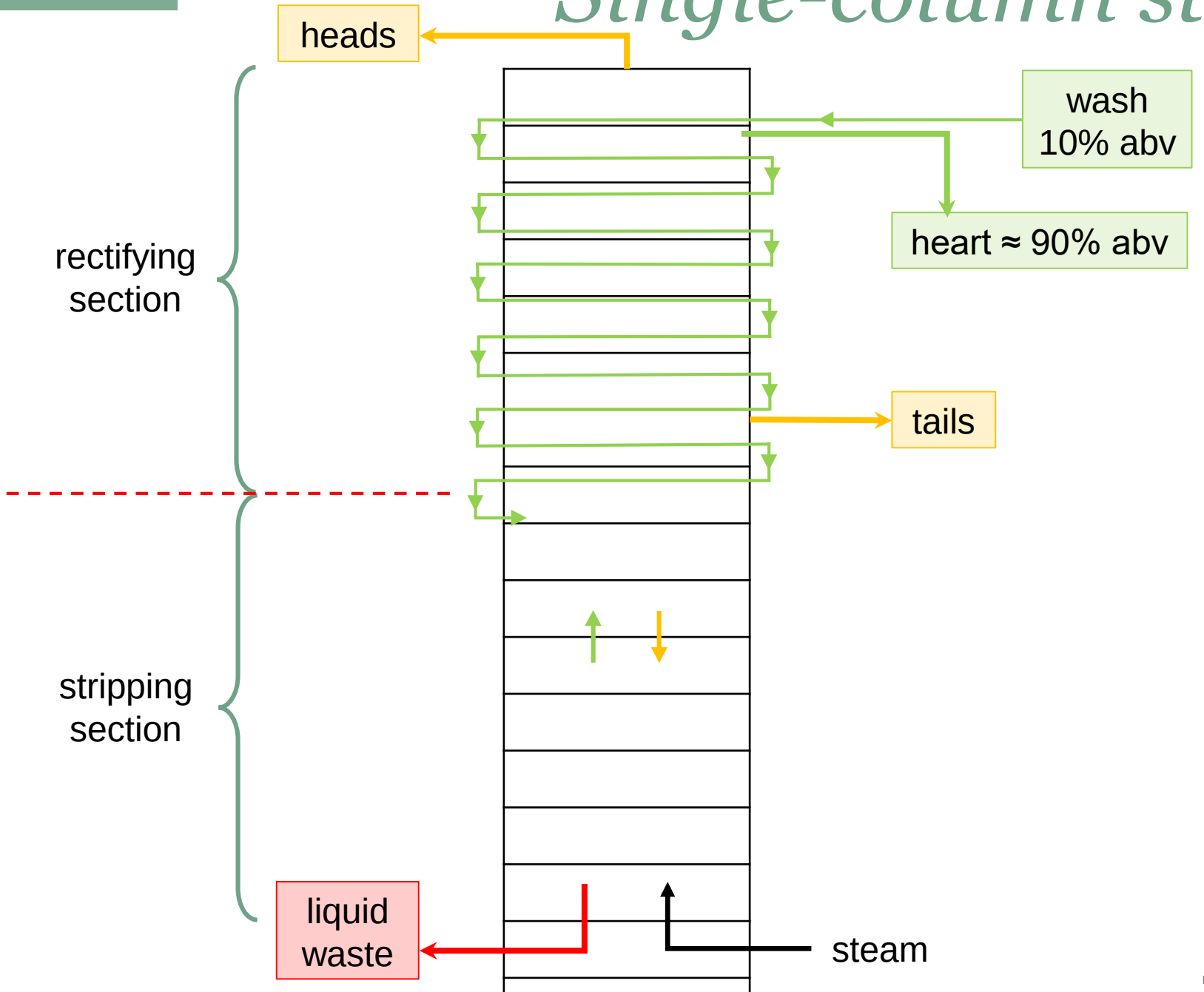
Single-column still



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Column still distillation

Approaches covered in detail

- single-column
- double-column / Coffey still *(session 3)*
- beer still + doubler or thumper *(session 4)*
- Armagnac *(session 6)*
- hybrid stills *(session 7)*
- multiple-column stills *(session 11)*

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Stage 4: Post-distillation operations

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Stage 4: overview

Colour and clarity

+ oak vessels
+ oak alternatives *(session 4)*
+ caramel colour (E150a) *(session 3)*
+ other natural and artificial colours *(sessions 11 and 12)*
- chill-filtration *(session 3)*
- activated charcoal filtration *(session 9)*

Flavour

+ oak vessels/alternatives
+ inert vessels
+ botanicals, animal and other flavours *(sessions 11 and 12)*
- carbon filtration *(sessions 4, 9 and 11)*

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Stage 4: overview

Alcohol level

+ water *(session 11)*
+ *faibles* *(session 6)*

Sweetness

+ sugar *(sessions 6, 9 and 12)*

Texture

+ oak
+ other additives *(sessions 6, 10 and 11)*
- various filtration techniques *(sessions 4, 9 and 11)*

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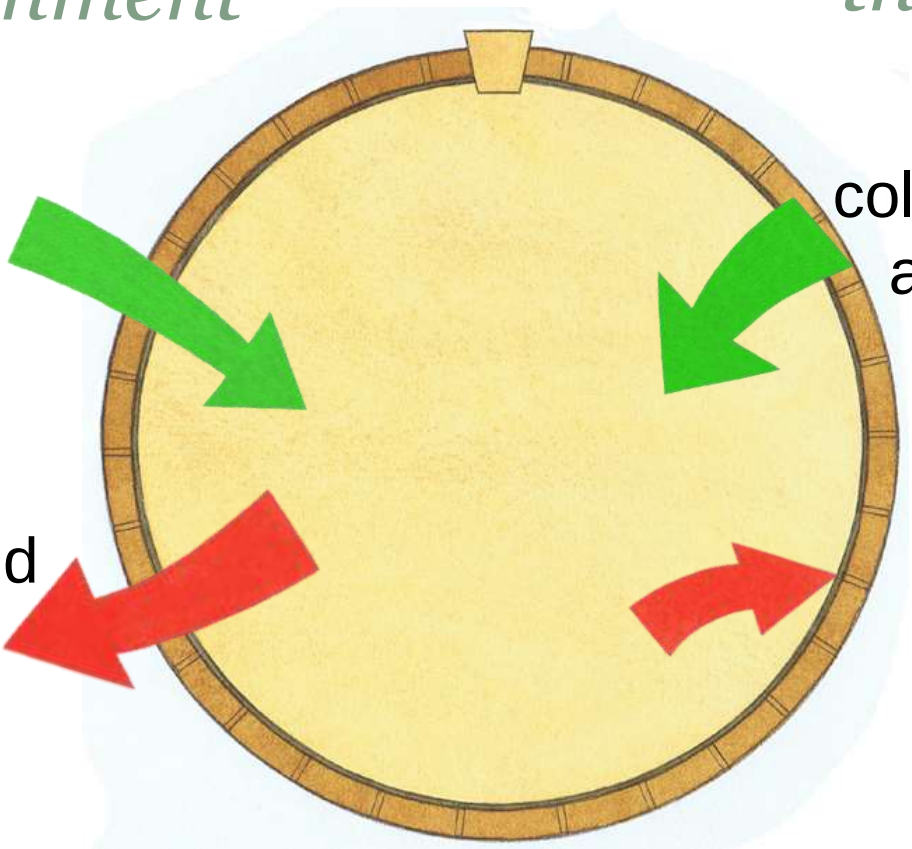
Key functions of oak vessels

Interaction with the environment

Interaction with the oak



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Vessel's design

Species of oak

- American
- European

Size (common examples)

- ASB
- Sherry butt
- larger formats

Vessel's design

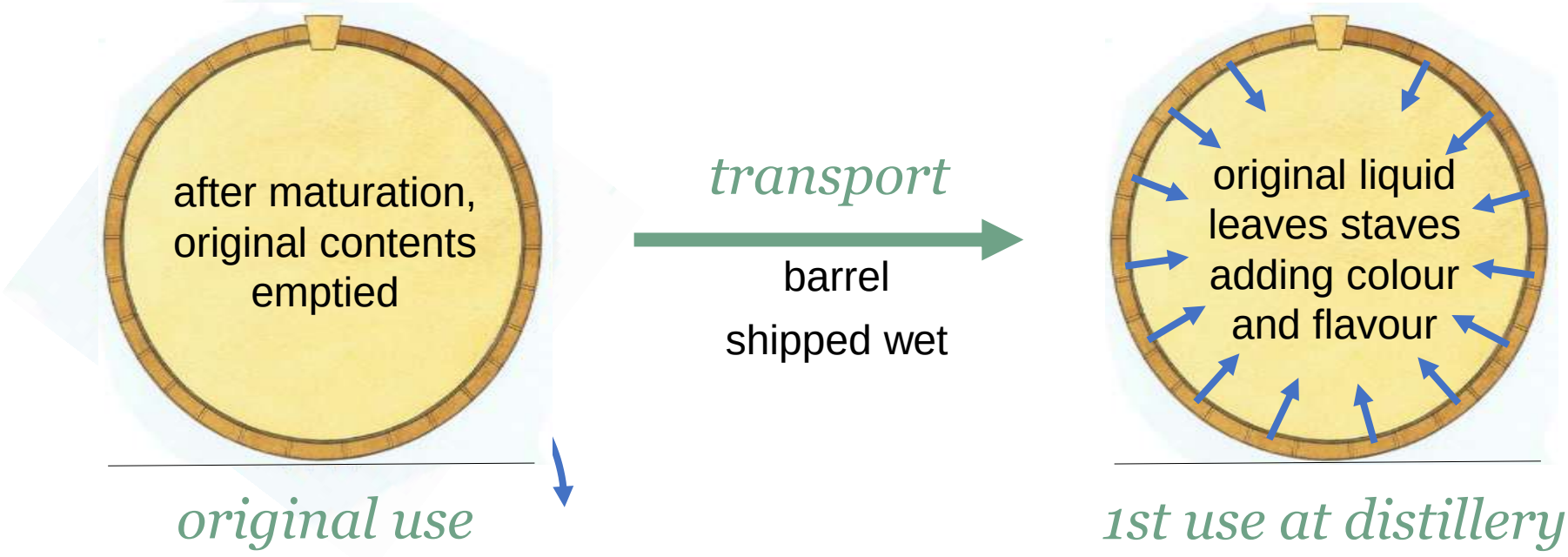
Vessel's previous use

Age

- number of uses
- refreshing (re-char)

Previous contents

- sulfur taint



Vessel's previous use

An oak vessel in use

Fill Strength

- *typically* 60-63% abv

style and warehouse costs

Temperature

- hotter = faster
- cooler = slower

affects level of extraction and speed of maturation

Humidity

- relatively dry = abv rises
- relatively humid = abv drops

Time

- rancio
- esterification

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Inert vessels

Storage

- no change
- e.g. vodka

Maturation

- development of flavour and mouthfeel
- e.g. some fruit spirits and grappa

Preservation

- after extended oak maturation
- e.g. Cognac

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Blending and Packaging

Blending

- consistency
- complexity

Containers

- glass
- PET

Closures

- screw caps
- stoppers

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